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(US). RING, Lev [US/US]: 14126 Heatherhill Place,
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(74) Agent: MATTINGLY, Todd; Haynes and Boone, LLP,
Suite 3100, 901 Main Street, Dallas, TX 75202 (US).

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(71) Applicant (*for all designated States except US*): ENVEN-
TURE GLOBAL TECHNOLOGY [US/US]: 16200 A.
Park Row, Houston, TX 77084 (US).

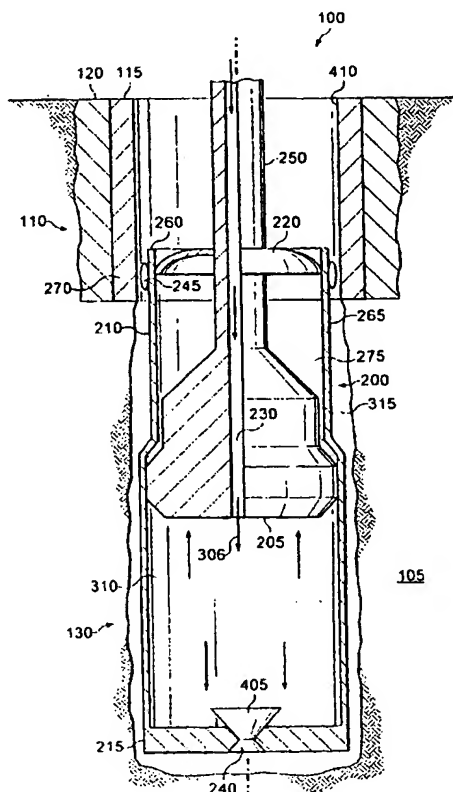
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(72) Inventors; and

(75) Inventors/Applicants (*for US only*): SHUSTER, Mark

[Continued on next page]

(54) Title: SELF-LUBRICATING EXPANSION MANDREL FOR EXPANDABLE TUBULAR



(57) Abstract: A self-lubricating expansion mandrel (205) includes
a system for lubricating the interface between the self-lubricating ex-
pansion mandrel (205) and a tubular member (210) during the radial
expansion of the tubular member (210).

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US03/25675

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : E21B 23/00, 43/10

US CL : 166/207, 55.7

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 166/207, 55.7, 50, 55, 55.1, 205, 209, 216, 242.1, 297, 380, 384

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Continuation Sheet**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2002/0062956 A1 (MURRAY et al.) 30 May 2002 (30.5.2002), whole document	1-9
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Y		10-23
Y	US 5,014,779 A (MELING et al) 14 May 1991 (14.05.1991), column 3, lines 31-36	19-23
Y	US 4,526,839 A (HERMAN et al) 2 July 1985 (02.07.1985), column 5, line 60- column 6, line 16.	10-18, 23
A	US 6,325,148 B1 (TRAHAN et al) 4 December 2001, (04.12.2001), whole document	1-23
A	US 3,203,451 A (VINCENT) 31 August 1965 (31.08.1965), whole document.	1-23
A	US 6,158,963 A (HOLLIS et al) 12 December 2000 (12.12.2000), whole document.	1-23
A	US 4,505,987 A (YAMADA et al.) 19 March 1985 (19.03.1985), whole document.	1-23

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"E" earlier application or patent published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

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later documents published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X"

document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y"

document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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document member of the same patent family

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11 December 2003 (11.12.2003)

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P.O. Box 1450
Alexandria, Virginia 22313-1450

Facsimile No. (703) 305-3230

Authorized officer

David J. Bagnell

Telephone No. (703) 308-1113

INTERNATIONAL SEARCH REPORT

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Continuation of B. FIELDS SEARCHED Item 3:
JPO, EPO, Derwent

Terms: swedge/swage, lubricate/lubricant, teflon, friction, coating,

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(71) Applicant (*for all designated States except US*): **ENVEN-
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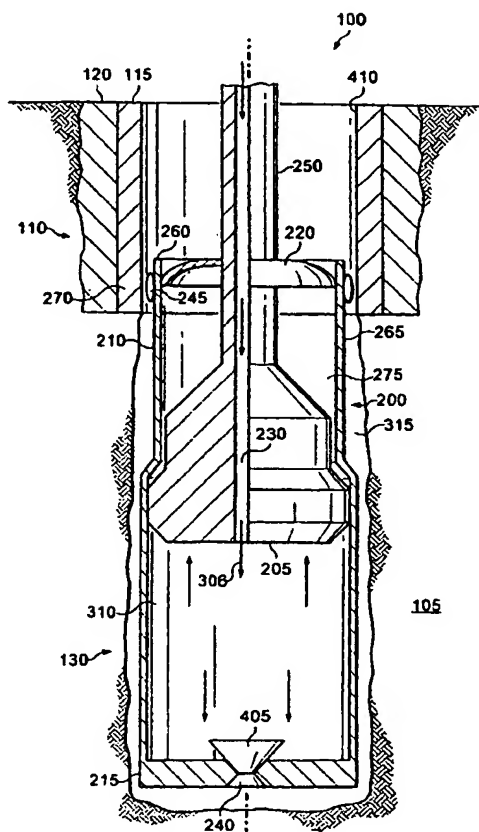
(72) Inventors; and

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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1

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AMENDED CLAIMS

[received by the International Bureau on 23 July 2004 (23.07.2004);
claims 24-47 added]

17. The self-lubricating expansion mandrel of claim 12, wherein the solid lubricant retained in the plurality of troughs formed in a textured pattern comprises a thermo-sprayed coating.
18. The self-lubricating expansion mandrel of claim 12, wherein the depth of the plurality of troughs formed in a textured pattern is in a range of between about 50 and 150 microns.
19. A self-lubricating expansion mandrel for expanding a tubular member, comprising:
 - a housing including a tapered outer surface;
 - one or more grooves formed in the tapered outer surface; and
 - a grease supply chamber in the housing;
 - a conduit from the grease supply chamber to one or more of the grooves; and
 - means for forcing grease from the grease supply chamber through the conduit to one or more of the grooves.
20. The self-lubricating expansion mandrel of claim 19, wherein the one or more grooves comprise circumferential grooves.
21. The self-lubricating expansion mandrel of claim 19, wherein the grooves comprise axial grooves.
22. The self-lubricating expansion mandrel of claim 19, wherein the grooves comprise a pattern of grooves with both an axial and a circumferential component.
23. The self-lubricating expansion mandrel of claim 22, wherein the pattern of grooves comprises a textured surface.
24. A self-lubricating expansion mandrel for expanding a tubular member, comprising:
 - a housing including a tapered outer surface;
 - one or more grooves formed in the tapered outer surface; and
 - solid lubricant retained in one or more of the grooves;
 - wherein the grooves comprise circumferential grooves.
25. A self-lubricating expansion mandrel for expanding a tubular member, comprising:
 - a housing including a tapered outer surface;
 - one or more grooves formed in the tapered outer surface; and
 - solid lubricant retained in one or more of the grooves;
 - wherein the grooves comprise axial grooves.
26. A self-lubricating expansion mandrel for expanding a tubular member, comprising:
 - a housing including a tapered outer surface;
 - one or more grooves formed in the tapered outer surface; and
 - solid lubricant retained in one or more of the grooves;
 - wherein the grooves comprise a pattern of grooves with both an axial and a circumferential component.
27. A self-lubricating expansion mandrel for expanding a tubular member, comprising:
 - a housing including a tapered outer surface;
 - one or more grooves formed in the tapered outer surface; and

solid lubricant retained in one or more of the grooves;

wherein the pattern of grooves comprises a textured surface.

28. A self-lubricating expansion mandrel for expanding a tubular member, comprising:

a housing including a tapered outer surface;

one or more grooves formed in the tapered outer surface; and

solid lubricant retained in one or more of the grooves;

wherein the depth of the grooves is in a range of between about 1 and 4 microns.

29. A self-lubricating expansion mandrel for expanding a tubular member, comprising:

a housing including a tapered outer surface;

one or more grooves formed in the tapered outer surface; and

solid lubricant retained in one or more of the grooves;

wherein the depth of the grooves is in a range of between about 10 and 50 microns.

30. A self-lubricating expansion mandrel for expanding a tubular member, comprising:

a housing including a tapered outer surface;

one or more grooves formed in the tapered outer surface; and

solid lubricant retained in one or more of the grooves;

wherein the solid lubricant retained in one or more of the grooves comprises a thermo-sprayed coating.

31. A self-lubricating expansion mandrel for expanding a tubular member, comprising:

a housing including a tapered outer surface;

one or more grooves formed in the tapered outer surface; and

solid lubricant retained in one or more of the grooves;

wherein the depth of the grooves is in a range of between about 50 and 150 microns.

32. A self-lubricating expansion device for expanding a tubular member, comprising:

a housing including a tapered outer surface;

one or more depressions formed in the tapered outer surface; and

a lubricant supply chamber in the housing;

a conduit from the lubricant supply chamber to one or more of the depressions; and

means for forcing lubricant from the lubricant supply chamber through the conduit to one or more of the depressions.

33. The self-lubricating expansion mandrel of claim 32, wherein the one or more depressions comprise circumferential grooves.

34. The self-lubricating expansion mandrel of claim 32, wherein the depressions comprise axial grooves.

35. The self-lubricating expansion mandrel of claim 32, wherein the depressions comprise a pattern of grooves with both an axial and a circumferential component.

36. The self-lubricating expansion mandrel of claim 35, wherein the pattern of grooves comprises a textured surface.

37. A self-lubricating expansion device for expanding a tubular member, wherein the interface between the expansion device and the tubular member, during the expansion process, includes a leading edge portion and a trailing edge portion, comprising:

a housing including a tapered outer surface;

one or more first depressions formed in the leading edge portion of the tapered outer surface; and

a lubricant supply chamber in the housing;

a conduit from the lubricant supply chamber to one or more of the first depressions;

means for forcing lubricant from the lubricant supply chamber through the conduit to one or more of the depressions;

one or more second depressions formed in the trailing edge portion of the tapered outer surface; and

a solid lubricant provided within one or more of the second depressions.

38. The self-lubricating expansion mandrel of claim 37, wherein one or more of the first and second depressions comprise circumferential grooves.

39. The self-lubricating expansion mandrel of claim 37, wherein one or more of the first and second depressions comprise axial grooves.

40. The self-lubricating expansion mandrel of claim 37, wherein one or more of the first and second depressions comprise a pattern of grooves with both an axial and a circumferential component.

41. The self-lubricating expansion mandrel of claim 40, wherein the pattern of grooves comprises a textured surface.

42. A method of lubricating the interface between an expansion device and a tubular member during an expansion of the tubular member using the expansion device, wherein the interface between the expansion device and the tubular member comprises a leading edge portion and a trailing edge portion, comprising:

injecting a fluid lubricant into the leading edge portion; and

providing a solid lubricant in the trailing edge portion.

43. A system for lubricating the interface between an expansion device and a tubular member during an expansion of the tubular member using the expansion device, wherein the interface between the expansion device and the tubular member comprises a leading edge portion and a trailing edge portion, comprising:

means for injecting a fluid lubricant into the leading edge portion; and

means for providing a solid lubricant in the trailing edge portion.

44. A method of lubricating the interface between an expansion device and a tubular member during an expansion of the tubular member using the expansion device, wherein the interface between the

expansion device and the tubular member comprises a leading edge portion and a trailing edge portion, comprising:

providing a supply of a fluid lubricant within the expansion device; and
injecting the fluid lubricant into the leading edge portion.

45. A system for lubricating the interface between an expansion device and a tubular member during an expansion of the tubular member using the expansion device, wherein the interface between the expansion device and the tubular member comprises a leading edge portion and a trailing edge portion, comprising:

means for providing a supply of a fluid lubricant within the expansion device; and
means for injecting the fluid lubricant into the leading edge portion.

46. A method of lubricating the interface between an expansion device and a tubular member during an expansion of the tubular member using the expansion device, wherein the interface between the expansion device and the tubular member comprises a leading edge portion and a trailing edge portion, comprising:

providing a supply of a solid lubricant on the expansion device within the trailing edge portion.

47. A system for lubricating the interface between an expansion device and a tubular member during an expansion of the tubular member using the expansion device, wherein the interface between the expansion device and the tubular member comprises a leading edge portion and a trailing edge portion, comprising:

means for providing a supply of a solid lubricant on the expansion device within the trailing edge portion.